Ultrafast laser bonding of dissimilar materials ready for industrial uptake

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Bonding of metals to transparent materials (glass, quartz, sapphire, etc.) is frequently needed in modern manufacturing including for hermetic sealing and precise optical parts positioning. It is currently achieved using organic adhesive or frit interlayers as well as diffusion, anodic and arc bonding. Such techniques can be lengthy, introducing large heat deposition and are subject to post-process creep and outgassing, all of which are highly undesirable and limit the extent of material combinations possible to join. Recently [1] direct bonding of glass to metal (BK7 and fused silica to Al) has been demonstrated utilising ultrafast lasers which offer high precision, high process speed and very small heat affected zones. The process relies on high laser intensity from sub-10 picosecond duration beams which are tightly focused through the glass, triggering non-linear absorption ionisation and plasma formation in a highly localised volume of few microns width near the glass-metal interface [2]. This, combined with heat accumulation from high pulse repetition rate above 200kHz, results in a narrow melt zone of ~0.1mm around the irradiated region, which solidifies behind the translated laser beam forming a strong bond across a user-defined beam trajectory.

Innovate UK funded consortium "Ultraweld" was established to upscale this process to a higher TRL level 6 as there are still manufacturing challenges relating to precise focal position control, contacting gap size and pre-conditioning of surface quality. An ultrafast laser prototype has been designed and built and we will show here that sub-10ps laser microwelding of (i) 10mm thick bulk optics to flat metal parts as well as (ii) conductive layer coated thin flexible glass to glass is possible with sufficient bond strength for use in industrial applications such as aerospace electro-optics assembly and flexible electronics hermetic sealing [3]. This prototype commercial laser welding machine will be suitable for other optical material welding applications (e.g. glass to silicon; glass to ceramic, Nd:YAG to metal, etc.).

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